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Uncertainty of the Future as a Fundamental Problem of the Long-Term Development of Transport

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ABSTRACT

The article is devoted to consideration of the problem of long-term development of transport under the conditions of uncertainty, which is a fundamental feature of the conditions of human activity. The objectives are to reveal the specifics of the «path dependence» in the field of transport, to show the fundamental nature of the problem of uncertainty of human activity and its special significance for development of transport, to propose a methodological basis for mitigating the problem of uncertainty in the long-term development of transport.

While achieving the objectives, it is shown using historical analysis that the development of transport systems forms a specific kind of «path dependence», having a significant long-term impact on the future of not only transport itself, but also on other sectors of the economy, as well as on the development of demographic and other social processes.

The location of the population, the development of production capacities, the choice of places of recreation are adapted to the existing transportation network. The decisions regarding location of transport infrastructure, the configuration of transport networks, the use of various technical solutions significantly influence the future of the transport itself.

In this regard, it is desirable to reduce the uncertainty of the future of the transport. Uncertainty does not mean absolute unawareness. Although the future cannot be predicted accurately, it can be predicted with a certain probability. It is necessary, while fully understanding the impossibility of achieving complete certainty in predicting the future, to assess, at least at a qualitative level, the probability of these forecasts, strive to increase it and to develop transport systems considering the greater or lesser likelihood of certain forecasts.

Hence, it is recommended to use both the logical-analytical method as the basis for forecasting long-term development to identify and consider long-term trends in the development of transport, and the foresight and predictive analytics to reveal newly emerging trends. An important condition of success is the ability to develop and implement various alternative solutions in response to emerging challenges, requiring development of a competitive and innovative environment both in the field of transport and in related areas of economic activity.

Keywords: *transport, infrastructure, investment, path dependence, uncertainty, progress, long-term development.*

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Transport vehicles and particularly transport infrastructure are characterized by high capital intensity and a long life cycle. It is confirmed by the established useful life of fixed assets in the transport field. For example, the useful life of the roadbed of railways is 100 years, for railway platforms and high-speed trains it is up to 40 years, while for locomotives and freight cars it is up to 28 years.

At the same time, investments in the transport sector, and particularly, again, investments in transport infrastructure pay off more slowly than in many other sectors. If we study the Russian example, it is noteworthy that in a centrally planned economy, the normative payback period for investments in transport was longer than in industry [1, p. 52]. Then [*with the market restructuring*], this problem did not disappear, but worsened. Thus, according to estimates of B. M. Lapidus, «tough state regulation of tariffs with underestimation of their indexation» led to the fact that only for the period 2000–2013 «conditions for the return on investment in railway infrastructure deteriorated by about half» [2, p. 4]. Since then no significant improvement in those conditions has occurred.

Generally, and this is a world-wide trend, the economic and social importance of transport infrastructure is extremely high. Transport infrastructure can generate ultra-long-term, «secular» socio-economic effects [3, pp. 76–77], certainly only if this infrastructure, considering its necessary modernization, will be in demand for such a long period.

The *objectives* of this study are:

• to reveal the specifics of the «path dependence» in the field of transport, which determines the extreme importance of long-term decisions not only for the industry itself, but also for the economy as a whole, for social development;

• to show the fundamental nature of the problem of uncertainty of human activity and its special significance for development of transport, considering long-term implementation of capital-intensive transport projects and even more long-term effects of their implementation;

• to propose a methodological basis for mitigating the problem of uncertainty in decision-making concerning the long-term development of transport.

To achieve these goals, the logical-analytical method and the method of historical analysis are used, while the necessity of combining foresight methods and predictive analytics with feasibility studies is substantiated.

The paper is to some extent a logical follow-up and a generalisation of a series of author's researches devoted to the problems of development of transport [particularly, 3; 5–6; 8–9; 14; 23–26; 37–38].

«**Path dependence**»

When assessing the long-term development of transport, one should consider such a phenomenon as «path dependence». This is a term primarily from the institutional theory, implying a dependence of development of society on the past path, institutional inertia [4, p. 117]. But development of society and economy depends not only on the «institutional path», but also on the «transport path[1]» which includes the prevailing transportation technology, the geography of communications, the location of transport terminals, etc. The location of the population, the development of production capacities, the choice of places of recreation are adapted to the existing transport network.

Already in ancient times, cities as economic, social, and cultural centers arose and developed along water and land transport routes, and especially at the intersection of such routes [5, p. 231].

In the Middle Ages in Western Europe, in the context of degradation of the Roman road network, «land trade and transportation hubs fell into decay, giving way to those located on the banks of rivers» [6, p. 229]. Accordingly, the geography of Western European cities was also redrawn [7, pp. 36–37]. In turn, «most of the ancient Russian cities arose along strategically significant sections of river communications, including in places of portage, where ships were dragged and carried over land from one river to another» [6, p. 229].

The construction of pioneer railways in the eastern regions of Russia and the western regions of the United States in 19th and early 20th centuries significantly influenced economic

[1] The author in original Russian text also uses here and below the effect of the homonymy in Russian language of the core word in phrases «path dependence», «railway gauge», «wheel track» that opposite to English language has the same spelling in all cases. – *ed. note.*

and demographic processes. So, at present all the largest cities of Siberia and the Far East are located on the main course of the Trans-Siberian Railway, and the most significant town of Novosibirsk has arisen thanks to the construction of this very long main line [8]. At the same time, such Siberian cities as Tobolsk and Tomsk, which had been important in the past, turned out to be away from the main railway route, and hence lost their former significance [9, p. 165].

In the USA, «every railway, wishing to increase profits, the cost of land and invested capital, did everything possible to attract immigrants and ensure economic development in neighboring territories. And this caused an active response, people were removed from their places and moved to cities, ports and lands served by competing railways» [10, p. 231].

Estimates made by the winner of the 1993 Nobel Memorial Prize in Economic Sciences Robert W. Fogel showed that if there were no railways in the USA and if other modes, especially inland waterways, were developed instead of railways, then the regional distribution of productive forces and population would be completely different [11; 12].

Urban planning decisions that were made many decades, and sometimes centuries ago, also make today's vehicles and people adapt to them. Moreover, those adaptive capabilities are usually limited and do not allow for high speed and ease of use of transport, cause traffic jams, extra travel time, and, no less important, the uncertainty of duration of travel [13; 14]. The published annual ranking of cities with the busiest streets and roads indicates that in many of them each driver loses more than 100 or even 200 hours a year in traffic jams, and the average speed of traffic in the city center does not exceed 20 km/h [15].

The decisions on placement of transport infrastructure facilities, development of configuration of transport networks, the use of various technical solutions have a significant impact on the future of the transport itself.

So, the choice of places for construction of airports for many years determines the routes of airlines, and decisions on placement of marshalling yards on railways predetermine organization of train flows.

The chronological antecedence of the use of direct current electrification on the railways and simplicity of design of direct current electric locomotives led to its widespread use in many countries, including in Russia [16, p. 44]. Its priority is still preserved, despite successful development in the second half of 20th century of alternating current electrification, which has significant technical and economic advantages [17, p. 212]. After all, changing the electrification system requires a huge investment, and this determines the choice in favor of continuing to operate DC systems and to further modernize them.

In the USA, where, for various reasons, electrification of railways did not develop and diesel locomotive traction dominates, the significant economic and environmental effects of electrification were not implemented. However, during the period of dynamic development of containerization of transportation, the absence of overhead catenary on the North American railways made it possible to proceed with two-tier container transportation quite easily. This dramatically reduces the cost of container transportation and increases the competitiveness of railways in the transportation market of high-value goods [18, p. 7].

A case in point is the choice of gauge. During the construction of the first railways, «few people thought that the gauge should be chosen based on development of a single network of railways in a country, or even more so through an entire continent. It seemed that this was a matter of the distant future» [16, p. 73]. Different railways in the same country could have different track gauges. For example, in the UK, the homeland of railways, five types of track gauge were used. When individual railway lines began to be connected into a single network, such a difference in gauge naturally began to cause great inconvenience in organization of the transportation process, slowing down and costing the delivery of goods and travel of passengers.

In Great Britain, the issue of switching to a single gauge was decided by Parliament by adoption of a special law in 1846. In the USA, where «at the end of the 1860s ... 12 variants of gauge were used» [19, p. 108], unification of the gauge was carried out only in the 1880s on the basis of lengthy negotiations between entities of the railway industry resulted in conclusion of the convention on introduction of a single gauge of US railways [16, p. 75]. Considering the fact that a large-scale railway network had been created in the country at that time, about 21 thousand km of tracks had to be changed to a single gauge, followed by replacement of thousands of cars and locomotives [16; 19].

It is evident that the more complex and capital-intensive the railway infrastructure and rolling stock became, the more difficult and more expensive it was to harmonize the gauge. Nowadays, the problem of connecting railways with different gauge is solved through using a dual (mixed) gauge, transshipment of goods from one wagon to another, change of car bogies and the use of variable-gauge wheelsets.

Thus, development of transport infrastructure (and hence, of rolling stock, which must be somehow harmonized with development of infrastructure [17]), due to high capital intensity and duration of the life cycle, forms a specific kind of «path dependence», i.e. it has a significant long-term impact both on development of transport itself and on development of other sectors of the economy, demographic and other social processes.

Therefore, the choice of various options for construction of transport infrastructure (railway, highway or canal), use of technical solutions (for example, a diesel or electric engine) entails long-term consequences for the efficiency of not only the industry, but also for general socio-economic development. Hence, such a choice is extremely responsible, and it would be highly desirable if it were based on a reliable assessment of these long-term consequences.

Progress and uncertainty

However, as Friedrich August von Hayek, the winner of 1974 Nobel Memorial Prize in Economic Sciences, pointed out, «progress consists in discovery of the unknown, its consequences must necessarily be unpredictable», the progress «by its very nature cannot be planned» [20, pp. 63–64].

This thought, in fact, is being developed by the rector of the Russian Presidential Academy of National Economy and Public Administration under the President of the Russian Federation V. A. Mau: «...That's the «charm» of progress ...that almost nothing can be said in advance» [21, p. 247]. This researcher emphasizes «the limited ability of man to draw unambiguous conclusions of a strategic nature, based on his own experience and common sense». «We don't know and basically can't know», which will be «a source of breakthrough in the future...» [21, p. 250]. The above example of organization of highly efficient two-tier transportation of containers in the USA in the absence of railway electrification confirms it well (indeed, this example does not indicate inappropriateness of electrification, but only shows that development of seemingly less perfect diesel locomotive traction can result in such positive but probably unintended consequences).

The unpredictability of the progress, of all the possible long-term consequences of decisions made, is a consequence of the fundamental problem of uncertainty of the future. «The uncertainty of the future is already implied by the very concept of activity. ...The fact remains that the future is hidden from the current person. ...We can practically predict the performance of a machine designed according to the rules of scientific technology. But the development of a machine is only part of a broader program aimed at providing consumers with the products of this machine. ...The degree of certainty regarding the technological result of creating a machine, no matter how high it may be, does not exclude the high uncertainty inherent in all activities. Future needs and assessments, people's reaction to changing circumstances, future scientific and technological knowledge ...can't be predicted otherwise than with a greater or lesser degree of probability» [22, pp. 101–102].

The cited extensive quotation is particularly important for understanding the problem. Uncertainty is a fundamental characteristic of the future associated with the very nature of human activity, and no development of mathematical models, methods and volumes of information processed can completely overcome this uncertainty by developing exceptionally reliable forecasts.

Mitigating uncertainty

But uncertainty is not an absolute unawareness. The future cannot be predicted accurately, but it can be predicted with a certain («greater or lesser») probability. This probability is also a priori uncertain, but, evidently, the more distant prospect and the wider range of consequences are considered, the less likely is the prediction. For large-scale projects for development of transport infrastructure, for fundamental decisions that form the basis of

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innovations in the field of transport technology, which generate long-term economic and social consequences in various fields, the probability of predicting these consequences is rather less than greater. However, we emphasize again that this is not an absolute unknown. It is necessary, fully understanding the impossibility of achieving complete certainty in predicting the future:

• firstly, at least on a qualitative level, to evaluate the probability of implementation of these forecasts;

• secondly, to strive to increase their probability;

• thirdly, to carry out development of transport systems, considering the greater or lesser likelihood of implementation of certain forecasts. Indeed, «only because we can, and to the extent how we can predict events, or at least evaluate their probability, we are able to achieve anything» [20; p. 170].

The key to mitigating the uncertainty problem may be the use of the logical-analytical method [23; 24] and development on its basis of logical forecasts of long-term development (an example of such a forecast for transport is shown in [25]). It is important, on the one hand, to identify ultra-long-term trends in development of transport, such as an increase in speed of transport [26; 27] or their range [28], which are likely to remain the same also in forecasted future. And on the other hand, it is necessary to assess the prospects of just emerging new trends and phenomena, especially in the field of engineering and technology. For this, in particular, it is possible to use the foresight, which «involves the identification of *weak signals* of development of innovations and has the ability to «approximate» the onset of the future» [29, p. 27], as well as the scientific tools of predictive management [30]. When assessing the economic prospects of transport innovations, it is necessary to determine which global socio-economic challenges they meet and how their implementation will affect key indicators of transport activity [31; 32].

Given the fact that, as noted above, the future can be predicted only with some, more or less, probability, it is important to have the maximum number of alternative options for responding to challenges formed by both long-term development trends and emerging «weak signals». And for this, in turn, we need both competition of developers and manufacturers of transport equipment and technologies, and development of a competitive environment in the transport industry itself [33; 34]. Conditions for development of such an environment in the future are laid down, including by decisions adopted today on implementation of infrastructure projects. In this regard, we can quote the example of Russia, noting that the Comprehensive Plan for Development of the Main Infrastructure [35] approved by the Russian government has covered projects for various modes of transport, including those providing an alternative to consumers of transport services. For example, the above plan envisages both Moscow–Kazan high-speed railway[2] with the prospect of its extension to Yekaterinburg and beyond, and Moscow–Nizhny Novgorod–Kazan high-speed highway.

It seems that implementation of major projects for development of the main infrastructure should be complemented by development of local infrastructure to make public transportation lines accessible to various economic entities. Such local projects should be implemented by private capital with participation of regions and municipalities, which requires development of the institutional environment, improving the investment climate and expanding the financial opportunities of the regions.

One of the possible ways to reduce the uncertainty of long-term technical solutions may be to shorten the life cycle of transport facilities, including infrastructure, which will require a corresponding reduction in the standard terms of their useful life and a corresponding increase in depreciation rates. Such an approach requires a deep comprehensive technical and economic assessment. It seems that it should be linked with the idea of a «closed-loop economy», which implies a «continuous cycle of processing materials that connects old and new products» [36, pp. 224–225]. This will help to increase the environmental friendliness of economic activity, and, in addition, will reduce the risks of increasing closure costs over significant periods of time if the life cycle of fixed assets is reduced.

Conclusion

The uncertainty of the future, being a fundamental property of human activity, is especially significant for the long-term development of transport. In order to mitigate the problem of uncertainty and increase the probability of predicting future transport, it is necessary to study the features of manifestation of general laws of human activity in transport, including economic laws [37], specific laws of transport development [38], as well as long-term trends and «weak signals», indicating the emergence of new phenomena and trends within this development. Identification and study of patterns of innovative development of transport is also of importance [39; 40].

One must be also aware that uncertainty is fraught not only with the risks of not achieving the intended objectives, but also with the possibility of discovering new, currently unknown, and unpredictable ways to achieve them. In order for these opportunities not to be missed, a competitive environment and favorable conditions for inventions and innovations are required, including the possibility of implementing a wide range of alternatives in the field of scientific research and development of new technical means and technology.

[2] In the Comprehensive Plan it is envisaged to construct its pilot section: Zheleznodorozhny–Gorokhovets with traffic from Moscow to Nizhny Novgorod.

REFERENCES

1. Economics of railway transport [*Ekonomika zheleznodorozhnogo transporta*]. Ed. by I. V. Belov. Moscow, 1989, 351 p.

2. Lapidus, B. M. About the contribution of JSC Russian Railways to formation of the country's GDP and the economic tasks of the company under tariff restrictions [*O vklade OAO «RZD» v formirovanie VVP strany i ekonomicheskikh zadachakh kompanii v usloviyakh tarifnykh ogranichenii*]. *Bulletin of the All-Russian Research Institute of Railway Transport*, 2014, Iss. 1, pp. 3–7.

3. Macheret, D. A. On the Economic Problems of Development of Transport Infrastructure. *World of Transport and Transportation*, 2011, Vol. 9, Iss. 3, pp. 76–83.

4. Auzan, A. Economics of everything. How institutions determine our lives [*Ekonomika vsego. Kak instituty opredelyayut nashu zhizn*]. Moscow, Mann, Ivanov and Ferber publ., 2014, 160 p.

5. Macheret, D. A. Transport Factor in the Era of Ancient Civilizations. *World of Transport and Transportation*, 2014, Vol. 12, Iss. 2, pp. 230–241.

6. Macheret, D. A. Socio-Economic Role of Transport in the Middle Ages. *World of Transport and Transportation*, 2015, Vol. 13, Iss. 2, pp. 228–237.

7. Le Hoff, J. Civilization of the medieval West [*Tsivilizatsiya srednevekovogo Zapada: Trans.from French*]. Yekaterinburg, U-Factoria publ., 2007, 560 p.

8. Macheret, D. A. Socio-Economic Assessment of Transport on the Basis of Historical Comparisons. *World of Transport and Transportation*, 2016, Vol. 14, Iss. 1, pp. 256–271.

9. Macheret, D. A. Economic notes on domestic railways [*Ekonomicheskie zapiski ob otechestvennykh zheleznykh dorogakh*]. *Otechestvennie zapiski*, 2013, Iss. 3, pp. 162–176.

10. Rothbard, M. Towards a new freedom: the libertarian manifesto [*K novoi svobode: Libertarianskiy

manifest: Trans. from English]. Moscow, New Publishing House, 2009, 398 p.

11. Fogel, R. W. Notes on the Social Saving Controversy. *Journal of Economic History*, 1979, Vol. 39, Iss. 1, pp. 1–55.

12. Fogel, R. W. Railroads and American Economic Growth: Essays in Econometric History. John Hopkins University Press, 1964, 296 p.

13. Macheret, D. A. Economy of Bottle Necks. *World of Transport and Transportation*, 2014, Vol. 12, Iss. 3, pp. 64–75.

14. Macheret, D. A. Time Multiplier in Transportation. *World of Transport and Transportation*, 2015, Vol. 13, Iss. 3, pp. 102–107.

15. INRIX global traffic scorecard. [Electronic resource]: http://inrix.com/scorecard/. Last accessed 13.02.2019.

16. Sotnikov, E. A. Railways of the world from 19th to 21st century [*Zheleznie dorogi mira iz XIX v XXI vek*]. Moscow, Transport publ., 1993, 200 p.

17. Macheret, D. A., Kudryavtseva, A. V., Ledney, A. Yu., Chernigina, I. A. General technical and economic course of railways [*Obshchiy tekhniko-ekonomicheskiy kurs zheleznykh dorog*]. Moscow, MIIT publ., 2017, 364 p.

18. Lapidus, B. M. Advanced development of railway transport – the choice of time [*Operezhayushchee razvitie zheleznodorozhnogo transporta – vybor vremeni*]. *Bulletin of the Joint Scientific Council of JSC Russian Railways*, 2018, Iss. 5–6, pp. 1–16.

19. Dobbin, F. Formation of industrial policy: the United States, Britain and France during formation of the railway industry [*Formirovanie promyshlennoi politiki: Soedinennie Shtaty, Velikobritaniya i Frantsiya v period stanovleniya zheleznodorozhnoi otrasli: Trans. from English*]. Moscow, Publishing House of the Higher School of Economics, 2013, 368 p.

20. Hayek, F. A. von. Freedom Constitution [*Konstitutsiya svobody: Trans. From English*]. Moscow, New Publishing House, 2018, 528 p.

21. Mau, V. A. Revolution: mechanisms, prerequisites and consequences of radical social transformations [*Revolyutsiya: mekhanizmy, predposylki i posledstviya radikalnykh obshchestvennykh transformatsii*]. Moscow, Publishing house of Gaidar Institute, 2017, 368 p.

22. Mises, L. von. Human activity: a treatise on economic theory [*Chelovecheskaya deyatelnost': traktat po ekonomicheskoi teorii: Trans. from English*]. Chelyabinsk, Socium publ., 2008, 878 p.

23. Macheret, D. A. Methodological problems of economic research in railway transport [*Metodologicheskie problem ekonomicheskikh issledovanii na zheleznodorozhnom transporte*]. *Ekonomika zheleznykh dorog*, 2015, Iss. 3, pp. 12–26.

24. Macheret, D. A. Vector of development of economic science in transport [*Vektor razvitiya ekonomicheskoi nauki na transporte*]. *Transport Rossiiskoi Federatsii*, 2017, Iss. 2, pp. 27–33.

25. Macheret, D. A. Transport component of the Economic system: Logical prognosis. *World of Transport and Transportation*, 2003, Vol. 1, Iss. 4, pp. 82–86.

26. Macheret, D. A. Analysis of the long-term dynamics of speeds in freight traffic [*Analiz dolgosrochnoi dinamiki skorostei v gruzovom dvizhenii*]. *Zheleznodorozhniy transport*, 2012, Iss. 5, pp. 66–71.

27. Macheret, D. A. Economic importance, trends and prospects for increasing speeds in railway transport [*Ekonomicheskoe znachenie, tendentsii i perspektivy povysheniya skorostei dvizheniya na zheleznodorzhnom transporte*]. *Bulletin of the Joint Scientific Council of JSC Russian Railways*, 2013, Iss. 2, pp. 13–23.

28. Macheret, D. A. The increase in the range of freight transportation – a fundamental trend in economic development [*Rost dalnosti gruzovykh perevozok – fundamentalnaya tendentsiya ekonomicheskogo razvitiya*]. *Ekonomika zheleznykh dorog*, 2015, Iss. 8, pp. 14–23.

29. Tretyak, V. P. Innovation and Foresight/ Conceptual problems of economics and transport management: a look into the future [*Innovatsii i forsait / Kontseptualnie problemy ekonomiki i upravleniya na transporte: vzglyad v budushchee*]. *Proceedings of National Scientific and Practical Conference*. Moscow, RUT (MIIT) publ., 2018, pp. 26–32.

30. Macheret, D. A., Valeev, N. A. Scientific toolkit for predictive management of railway transport efficiency [*Nauchniy instrumentariy prediktivnogo upravleniya effektivnost'yu zheleznodorozhnogo transporta*]. *Vestnik VNIIZhT*, 2018, Iss. 2, pp. 84–91.

31. Kudryavtseva, A. V. Socio-economic prospects of transport innovation [*Sotsialno-ekonomicheskie prespektivy transportnykh innovatsii*]. *Transport Rossiiskoi Federatsii*, 2017, Iss. 2, pp. 34–39.

32. Kudryavtseva, A. V. Methodology for assessing the socio-economic prospects of transport innovations [*Metodologiya otsenki sotsialno-ekonomicheskoi perpektivnosti transportnykh innovatsii*]. *Ekonomika zheleznykh dorog*, 2017, Iss. 4, pp. 62–68.

33. Guriev, A. I. Competition as a science fiction [*Konkurentsiya kak fantastika*]. *Vektor transporta*, 2014, Iss. 1, pp. 10–13.

34. Macheret, D. A. The essence of competition and the key conditions for its development on the transport infrastructure [*Sushchnost' konkurentsii i klyuchevie usloviya ee razvitiya na transportnoi infrastrukture*]. *Vektor transporta*, 2014, Iss. 1, pp. 18–21.

35. Government order dated September 30, 2018 No. 2101-r. On approval of the Comprehensive Plan for modernization and expansion of the main infrastructure for the period until 2024 [*Rasporyazhenie Pravitelstva ot 30 sentyabrya 2018 № 2101-r / Ob utverzhdenii Kompleksnogo plana modernizatsii i rasshireniya magistralnoi infrastruktury na period do 2024 goda*]. [Electronic resource]: https://www.garant.ru/products/ipo/prime/doc/71975292/. Last accessed 22.10.2018.

36. Marsh, P. The new industrial revolution. Consumers, globalization and the end of mass production [*Novaya promyshlennaya revolyutsiya. Potrebiteli, globalizatsiya i konets massovogo proizvodstva: Trans. from English*]. Moscow, Publishing House of the Gaidar Institute, 2015, 420 p.

37. Macheret, D. A., Ryshkov, A. V. Manifestation of the law of diminishing returns in conditions of limited development of railway infrastructure [*Proyavlenie zakona ubyvayushchei otdachi v usloviyakh ogranicheniya razvitiya zheleznodorozhnoi infrastruktury*]. *Ekonomika zheleznykh dorog*, 2014, Iss. 7, pp. 12–21.

38. Macheret, D. A. On the law of priority development of transport infrastructure [*O zakone operezhayushchego razvitiya transportnoi infrastruktury*]. *Ekonomika zheleznykh dorog,* 2018, Iss. 7, pp. 14–19.

39. Izmaikova, A. V. Waves of Railway Innovative Development. *World of Transport and Transportation*, 2015, Vol. 13, Iss. 5, pp. 26–38.

40. Lapidus, B. M. About the conditions and trends of evolution of transport and scientific-technical tasks of creation of vacuum levitation transport systems [*Ob usloviyakh I tendakhk evolyutsii transporta i nauchno-tekhnicheskikh zadachakh po sozdaniyu vakuumno-levitatsionnykh transportnykh system*]. *Bulletin of the Joint Scientific Council of JSC Russian Railways,* 2016, Iss. 4, pp. 1–17.

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